A Dynamic Organization in Distributed Constraint Satisfaction

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Abstract

We present a novel dynamic organization to solve DCSP(Distributed Constraint Satisfaction Problem). DCSP provides a formal framework for studying cooperative distributed problem solving[Yokoo 92]. To solve DCSP, we have developed a simple algorithm using iterative improvement. This technique has had great success on certain CSP(Constraint Satisfaction Problems)[Minton 90][Selman 92]. In our algorithm each agent performs iterative improvement and also plural agents can do in parallel. However, one drawback of this technique is the possibility of getting caught in local minima(which are defined specifically in our algorithm). LMO is a technique for escaping from local minima. It is summarized as follows:

When an agent(A1) gets caught in a local minimum,
(step 1) A1 sends its CSP(variables, domains and
constraints) to an agent(A2). A1 selects A2 such that
it shares violated constraints at that time. Ties are
broken randomly.
(step 2) A2 puts its CSP and A1's CSP together and
searches for all possible assignments with simple back-
tracking. After that, A2 performs iterative improve-
ment.

Besides escaping from local minima, LMO prevents agents
from getting caught in the same local minima as before.
Therefore our algorithm for DCSP is complete.

LMO is also the algorithm for a dynamic organization
since agents reassign the responsibilities of solving CSP
based on a developing view of the problem. As a dynamic
organization, LMO is characterized by grouping in re-
response to the conflicts(i.e., local minima) that arise during
problem solving. This produces the effect that the organi-
nization with LMO we call it the LMO organization) makes
groups depending on the number of local minima. That
is, when there are few local minima in a problem, the
LMO organization solves it in a distributed manner, and
when there are many, it does in a centralized manner.

To evaluate the performance of LMO, we have compared
the LMO organization with the following ones.

1. Distributed organization: This organization always
solves problems in a distributed manner. In this orga-
nization each agent performs iterative improvement. When one agent gets caught in a local minimum, all
agents change their assignments randomly and continue to perform iterative improvement.

2. Centralized organization: This organization always
solves problems in a centralized manner. In this orga-
nization, to begin with agents have to solve the leader
election problem. Then all agents(but the leader) send
their CSP to the leader. Finally the leader searches
for one solution with simple backtraking(the method
used in LMO). Note that agents solve the leader elec-
tion problem and send their CSP regardless of the
possibility of distributed problem solving.

In our experiments, for the problems with few local minima
the LMO organization solves them faster than the Cen-
tralized organization(because the cost of leader election
exceeds that of distributed problem solving), and for the
problems with many local minima it solves them faster
than the Distributed organization.

Finally, in LMO, we use backtracking as a method to help iterative improvement. We believe that this approach will be applicable to non-distributed CSP. That will be our future work.

References

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